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Development of a Questionnaire to Evaluate Students' Perceived Motivation towards Science Learning Incorporating ICT Tool

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Abstract

Evaluation is the formal determination of the quality or effectiveness of programme or curriculum. Ideally it should cover cognitive/psychomotor and affective (e.g. attitudes and motivation) aspects of learning. This paper reports the two stages of pilot studies for the development and validation of "Science Motivation–Scale" (SMS) questionnaire incorporating ICT tools in data analysis. SMS was designed to evaluate the changes of perceived levels of motivation among secondary students participated in a 'Problem-based Learning' (PBL) programme. During the first stage of pilot study, various indicators to evaluate motivation in science were explored with review of literature on pertinent motivation and constructivist theories, e.g. 'self-efficacy, attribution, self-determination, expectancy-value, interest' theories. For this purpose, a draft instrument with questionnaire items adapted from three validated instruments [i.e. 'Motivation towards STES education' (MOTS), 'Science motivation questionnaire' (SMQ) and 'Motivation strategies for learning questionnaire' (MSLQ)] was prepared and pilot-tested among secondary students from local schools. Tests on Reliability Analysis (RA), Factor Analysis (FA) and mean correlation were conducted to yield evidences regarding reliability and validity of the instruments using SPSS statistics software with its technical features illustrated. Based on statistical analysis and feedback by student respondents and teachers, 52 items were first adapted as 'Science Motivation Scale' (SMS). During the second stage of pilot study, the SMS questionnaire was refined at least twice among secondary students of different gender and diverse background or levels of achievement. This paper reports only on the pilot studies with the first samples consist of mainly moderate students (N_1=160) and the second samples mainly high achievers (N_2=182) from three local schools. The conduct of FA via varimax rotation yielded the following 7 coherent groups as motivational subscales for the 25-item revised SMS, i.e. (1) self-efficacy (2) expectancy (3) intrinsic motivation (4) anxiety (5) values belief (6) aspiration and (7) perceived worthiness. Further statistical analysis also showed the acceptable range of Eigenvalue and Variance for SMS instrument to be a valid instrument. It was found that the refined versions of SMS questionnaire had relatively high reliability, ranged from approximately 0.68 to 0.92 for all 7 subscales and relatively low average mean correlation ranged from 0.17 to 0.49.

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Introduction

Evaluation as defined in education is the formal determination of the quality, effectiveness, or value of a programme, project, product, process, objective, or curriculum. Whereas *assessment* should be an integral part of teaching, not only as a tool to collect data, but also to influence instruction (Tej, 1990). *Evaluation* is also the process of making carefully determined value judgments and decisions related to the issues and concerns a given *assessment* has focused on, e.g. student achievement or programme quality. Assessment/evaluation is part and parcel of teaching, learning and instructional practices that should be carried out by teachers at various stages of teaching processes. 'Assessment' is not meaningful and helpful if no connection was made with 'instruction' as both are related (Higuchi, 1995)

In addition, *assessment* is the process of documenting including effort to collect quantitative or qualitative data, usually in measurable terms, to assess students' gains in knowledge, skills, attitudes and beliefs (Wikipedia, 2007). Thus the assessment or evaluation of students' performances should ideally cover cognitive (i.e. knowledge/intellectual), affective (e.g. values, attitude, interest and motivation) or social and psychomotor aspects of learning in line with the specific requirement of the particular lessons.

However, in most educational practices, more emphasis is given on reporting assessment or evaluation of students' learning performances that reflect their cognitive growth. Practically relatively few evaluative studies were conducted to illuminate students' growth in the aforementioned affective domains of learning, e.g. motivation.

This paper reports part of a bigger scale of study related to a specially designed Problem-based Learning (PBL) programme. The main aim of this article is to elaborate on the development and validation of "Science Motivation Scale" (SMS) with the following objectives:

- To illustrate the construction and analysis of items in SMS that were devised to evaluate perceived level of motivation among students participated in PBL focusing on theme 'Water and Solution'.
- To report on pilot studies conducted with procedures to establish validity and reliability of SMS using SPSS statistics software.

Literature Review

This section will review relevant literature including framework of study that guide the direction of research activities. Literature research will also be made to explore essential elements/constructs for the assessment of motivation in science, including the issues identified as focus areas of this paper.

Motivation and constructivist theories explaining the essential elements of motivational constructs

Educational psychologists believe that student's *motivation* is influenced by a number of *beliefs*, *values*, *interests* and *attitudes* that can be positive or negative in their effects. It is believed that students are motivated to learn when they *value* either the outcome or process of learning and they *expect* that they will be successful. As explained from psychological theories, they believe that the task is of value (*value beliefs*) and they believe he/she has the ability and confidence to succeed in the learning task (*expectancy* and *self-efficacy* beliefs). Self-efficacy is a very specific form of self-concept theory proposed by Bandura (1977) that refers to the confidence in one's ability to behave in such a way to produce a desirable outcome. Self-efficacy makes a difference in how people feel, think and act, such as in science related learning or activities. There are also other traits or distinguishing characteristics or quality that are interrelated or overlapped to some extent were identified as important for *motivation* towards Science, Technology, Environment, Society (STES) education as explained from motivation and constructivist theories. For example, highly *positively* motivated students would find the task inherently enjoyable (*intrinsic motivation*); have an established long-term interest in particular topics (*personal interest*) based on *interest* theory; have a desire to fully understand the content (*a mastery goal*); and believe that success will be related to effort (*an attribution*). According to Weiner (1979), the *attribution theory* for *motivation* stated students who believe that success is related to effort will be more likely to use effort than those who believe that success is due to inherent ability. When individuals have positive senses of effort, ability and efficacy, they are more likely to choose to do the task e.g. Problem-based Learning (PBL). This aspect will be reflected in the construct of motivation subscale with '*personal effort*' as intrinsic/internal control, i.e. the expectancy that one's own behavior determines rewards and punishments. The construct about '*self*' will be grounded on *self-determination* theory that stated students may do activities for interest or enjoyment (intrinsic motivation), and/or *self-efficacy* theory which stated when self-confidence is high, students will be more motivated to persist in a task until it is completed. The construct '*belief on own coping ability*' (intrinsic motivation) will be based on *Expectancy-Value* theory stating beliefs about one's ability to succeed are *expectancy beliefs*, beliefs about the extent to which the task is useful, enjoyable, or relates to one's self-image are *value beliefs* (Glynn, Taasoobshirazi & Brickman, 2007; Palmer, 2007; Phillips, 2007b; Weiner, 1979).

Constructivist and motivation theories recognize that *motivation* is influenced by how *interesting* and relevant the learners perceive the activities and information. Literature also revealed that *knowledge, skills and motivation are essential pre-conditions in scientific creativity* (Down, 1991 in Ng, 2005). According to Treffinger, et al. (2002), students' personal creative characteristics could be assessed based on four levels of present performance including '(1) Generating ideas; (2) Digging deeper into ideas; (3) Openness and courage to explore ideas; (4) Listening to one's *inner voice*'. People with characteristics in '*Digging deeper into ideas*' are '*improvement motivation*' and allow students who are creative to decide, evaluate, choose and develop promising options into creatively productive outcomes. The characteristics of '*Listening to one's inner voice*' is also often associated with self-awareness and motivational dispositions. It includes self-direction, awareness of creativeness, persistence or perseverance, internal locus of control, introspection, freedom from stereotyping, concentration, energy and work ethic. The creative people have a vision of where they want to go (i.e. with self-direction), a commitment to do whatever it takes to get there. They are aware of their passions, strengths and convictions. They possess a desire to create, have self-confidence to work toward their sense of purpose in life. Creative students are motivated to work hard and intensely concentrate on a subject or problem of interest. In other words, students learn to show that they can perform better than other people. This type of motivation is based upon the ego boost that comes about through social competition and is called '*achievement motivation*' that involve two major motives, i.e. the motive to 'achieve success' for ego enhancement that success brings, and to 'avoid failure' that involves the fear of losing face (Phillips, 2007b; Treffinger, et al., 2002).

Evaluating motivation supported by ICT tool considering validity and reliability

The review of motivation and constructivist theories identified a number of priorities as guidelines and indicators for the assessment/evaluation in motivation towards science. As stated, evaluation or assessment may involve the process of gathering and collecting information from multiple and diverse sources in order to develop a deep understanding of what students know, are motivated to do with their knowledge and perceive, feel or reflect as a result of their education experiences. Assessment or evaluation can be done in formal and informal ways. The modes of formal assessment can be varying. These may include paper-and-pencil tests, survey questionnaires with multiple choice and open-ended responses testing on students' knowledge, skills, perceived attitudes/motivation; oral, practical and performance tests on skills, to name a few. Whereas informal assessment can be done by observing students' attitudes, actions and behaviour; interviewing stakeholders on their perceptions; examining the daily work self report and reflective journals produced by students. But the researchers should be aware of certain aspects when choosing suitable assessment technique. For example, they should know that each method of assessment has its strengths and weaknesses. The methods and/or instruments used for assessment/evaluation should also have high validity and reliability. Understanding the basic guidelines and various indicators of evaluation/assessment on an aspect to be studied, e.g. the constructs that explain 'motivation towards science' help to increase its validity, reliability and usefulness.

The *validity* refers to whether the data collected actually reflect the phenomena to be observed or studied. It also means how far the test actually measures what it is supposed to measure. It is an indication of accuracy in terms of the extent to which a research conclusion corresponds to reality. There are various kinds of validity, such as construct validity, content or face validity, empirical validity, external validity, internal validity, predictive validity, to name a few (Heriot, 1975; Mischel, 1993). For example, *construct validity* is a determination of the significance, meaning, purpose, and use of scores from an instrument (Creswell, 2005).

Whereas *reliability* is the extent to which an assessment is repeatable and yields consistent scores. In order to be valid, a test must be reliable; but *reliability* does not guarantee *validity* (Wong, 2003). *Reliability* is normally measured using Cronbach Alpha (CA) test. *Coefficient Alpha* is an index of the extent to which items within a factor are measuring the *same broad construct*. Alpha coefficients are normally used to evaluate the internal consistency of the questionnaire or test as a whole, and the internal consistency of the pre-determined subscales of the test (Cronbach, 1951; Pedhazur & Schmelkin, 1991). Cronbach Alpha (CA) can be computed using ICT tool such as SPSS statistics software. CA can be improved by getting: (i) repeated measurements using the same test; and (ii) many different measures using slightly different techniques and methods. Although there are no hard and fast rules as to how many, or whether positive or negative items should be equally distributed, researchers are advised to prepare some negative items to ensure *reliability* or *internal consistency* of the instrument (Arellano, 2002).

Validity is often expressed in terms of a *correlation*. The *degree of reliability* is also normally expressed in terms of a *correlation*, i.e. the degree of relationship between two things. A high positive correlation would be in the range of 0.7 to 1, a moderate correlation from 0.4 to 0.7 and a low correlation from 0.2 to 0.4 (Heriot, 1975; Mischel, 1993). If the CA value of a subscale in a test is *high* or with positive correlation, the items in the subscale are considered good or *reliable* to measure the *underlying traits or characteristics* in this particular subscale. On the contrary, if the items in this sub-scale have low correlation with another scale, it means that these items are good to assess its own scale but are not good to measure the underlying traits of another scale. This feature is called *mean correlation* of a subscale. *Mean correlation* functions as a *convenient index* of *discriminant validity* that assesses the extent to which a subscale is unique in the dimension that it covers and is not assessed by other subscale in the same instrument. *Mean correlation* is also defined as *average correlation of a scale* with the other scales in the questionnaire. The lower the mean correlation the better the subscale is. Ideally the CA value should be below 0.4. However, sometimes due to the overlap of the various constructs, the range of CA values that fall between 0.4 to 0.6 are also acceptable (Wahyudi, 2004; Chokalingam, Wahyudi & Ng, 2009). Thus a good subscale must have high *Cronbach Alpha* value but low *mean correlation*. An example is *Water Attitude Scale* (WAS) that was developed by researchers recently to evaluate students' perception in Values-based Water Education (Yeap, Ng, Wahyudi, Cheah & Robert Peter, 2007).

Some of the major areas affecting the *validity* and *reliability* with regard to the quantitative versus qualitative research method including, the nature of the research questions posed; the source of the theory on which the study is anchored; the purpose of the investigation; the entry point and time frame for the investigation; the stance of the investigator; the appropriateness/trustworthiness or dependability of the methods and processes used; the instruments and devices used as well as the sampling and the reporting of the results. But there are some problems that constitute threats to validity that should be taken into consideration (Arellano, 2002; McBurney, 2001; Phillips, 2007a). In general, there are three types of threats to validity. The threats to *internal validity* are such as maturation (a source of error in an experiment related to the amount of time between measurements), regression effect (tendency of subjects with extreme scores on a first measure to score closer to the mean on a second testing), random error (the part of the value of a variable that can be attributed to chance), mortality (the attrition or dropping out of some subjects before an experiment is completed). The threats to *construct validity* are loose connection between theory and method as well as ambiguous effect of independent variable. These include *Hawthorne effects*, i.e. the possibility of the samples were aware that they were being tested and reacted to the knowledge that they were in an experiment rather than to the working conditions as such (McDonough, 1997). Other examples of threats are *good-subject tendency*, i.e. tendency of experimental participants to act according to what they think the experimenter wants; and *evaluation apprehension*, i.e. tendency of experimental participants to alter their behavior in order to appear as socially desirable as possible. The threats to *external validity* are questions whether the same results will be produced if the same experiment is conducted with other subjects, at another time and in other settings (McBurney, 2001). Unlike experimental research where validity is built in at the design stage, *validity* in qualitative research is progressively accomplished throughout the research process (Walker, 1989). The validity for both quantitative and qualitative research will be taken into consideration for mixed-research method, e.g. used in the aforementioned PBL study.

Indicators that may be arranged in hierarchical order serve as milestones to show the state of development or progress of students in the teaching and learning process or within a particular learning programme. Teachers can refer to the taxonomy of educational behaviours for both cognitive and affective domain for more knowledge and to enhance the ability to formulate indicators. For example, Krathwohl's taxonomy of educational objectives of *affective domains* includes the levels of receiving, responding, valuing, organisation, characterisation by value (Krathwohl, Bloom & Masia, 1956). The indicators in the affective domain focusing on the aspects of 'motivation towards science' that could be used in the aforementioned PBL programme may be formulated as below: "Students (a) find the task inherently enjoyable (*intrinsic motivation*); (b) have an established long-term interest in particular topics (*personal interest*); (c) believe he/she has the ability and confidence to succeed in the learning task (*expectancy* and *self-efficacy* beliefs); (d) believe that the task is of value (*task value beliefs*); (e) set learning goal and have a desire to fully understand the content (*goal orientation*); and (f) believe that success will be related to effort (*an attribution*). This list is not exhaustive and will be adapted based on common themes identified on the items constructed.

Methodology

This section will elaborate on the research activities that include the construction as well as analysis of items in the questionnaire entitled 'Science Motivation Scale" (SMS) with pilot studies conducted via data analysis using SPSS statistics software to establish reliability and validity of the instrument. In addition to observation and documentary analysis of learning output, SMS was one of the data source that was collected in the aforementioned PBL study for triangulation to evaluate the aspect of 'motivation towards science' among Form 2 students (ages about 13 or 14) in Case study School A and B. The following is a brief illustration of the process in devising SMS that was adapted from numerous validated research instruments including 'Science Motivation Questionnaire' (SMQ) by Glynn and Koballa (2006) with permission granted by the original author.

Constructing and piloting 'Science Motivation Scale' (SMS) from three questionnaires

"Science Motivation Scale" (SMS) was adapted from the following three instruments with review of literature on pertinent motivational models or theories. The first instrument (abbreviated as Q1 with originally 12 items) is '*Motivation towards STES education*' (MOTS) questionnaire (Ng, 2009). The second instrument (i.e. Q2 consisted of 30 items initially) is '*Science Motivation Questionnaire*' (SMQ) by Glynn and Koballa (2006) and the third instrument (i.e. Q3 consisted of 30 items initially) is '*Motivated Strategies for Learning Questionnaire*' (MSLQ) by Pintrich, Smith, Garcia and McKeachie (1993). Both the second and third questionnaires are validated instruments that were administered among students in Western countries with findings reported (Glynn, Taasoobshirazi & Brickman, 2007; Pintrich, et al., 1993). These instruments were adapted to suit the Malaysian contexts with the construction of item responses made consistent. For example, the rating scale of SMQ was modified from '1=Never, 2=Rarely, 3=Sometimes, 4=Usually, 5=Always' into '1=Strongly Disagree, 2=Disagree, 3=Somewhat Agree, 4=Agree, 5=Strongly Agree'. This is to ensure that when the items of the three questionnaires were adapted and combined into one final instrument, the rating scale will be consistent.

A draft instrument with questionnaire items adapted from the aforementioned three validated instruments i.e. MOTS, SMQ and MSLQ was prepared and first pilot-tested among secondary male and female students ages from 13 to 16 in three local schools between March and May 2008. After the analysis of data taking into consideration the aspects of reliability and validity to be elaborated, a new instrument entitled 'Science Motivation Scale' (SMS) was adapted from selected items in MOTS, SMQ and MSLQ. Tests on Reliability Analysis (RA), Factor Analysis (FA) and mean correlation were conducted to yield evidences regarding *reliability* and *validity* of the instruments. The procedures of RA, FA and mean correlation will be elaborated and illustrated in the "Data analysis" section.

Using the format of Likert Scale with ratings of 1 to 5, the respondents were required to circle the appropriate rating according to the direction given (i.e. 1=Strongly Disagree, 2=Disagree, 3=Somewhat Agree, 4=Agree, 5=Strongly Agree) in the following 'Motivation Scale' questionnaires. The items in these questionnaires were classified according to constructs that were named and refined based on the findings from RA, FA and mean correlation.

(1) 'Motivation towards STES education' (MOTS) questionnaire with four subscales

The main subscales derived as essential for *motivation* [to be explained from aspects *Locus of Control* (LOC) as *Attribution Theory*] towards learning in Science, Technology, Environment, Society (STES) are:

1. *Individual self-determination/self-efficacy/self-esteem* (*Intrinsic/internal LOC*) vs. Extrinsic belief system or factors influencing achievement (*Extrinsic/external LOC*).
2. *Personal skills/effort* (*Intrinsic/internal LOC*) vs. Influenced by powerful others/chance/fate/ luck/inborn ability (*Extrinsic LOC*).
3. *Belief on own individual coping ability*(*Intrinsic/internal LOC*) vs. Assistance from external factors or resources (*Extrinsic/external LOC*).
4. *Internal control/ability* (*Intrinsic/internal LOC*) vs. External task related difficulty in learning or other factor (*Extrinsic/external LOC*).

(2) **'Science Motivation Questionnaire' (SMQ) with five subscales**

The main constructs suggested by Glynn, et al. (2007) as essential for *motivation* (as explained from '*Self-determination,Expectancy-Value,Interest'* theories~~, refer *section 1.8*~~) towards science learning are:

1. *Intrinsic and extrincsic motivation*
2. *Goal orientation*
3. *Self-determination*
4. *Self-efficacy*

5. *Assessment anxiety*

(3) 'Motivated Strategies for Learning Questionnaire' (MSLQ) with six subscales
The main constructs suggested by Pintrich, et al. (1993) as essential for *motivation* (as discussed in '*Self-determination,Expectancy-Value,Interest*' theories~~, refer *section 1.8*~~) towards science learning are:

1. *Intrinsic goal orientation*
2. *Extrinsic goal orientation*
3. *Task value*
4. *Control belief of learning scale*
5. *Self-efficacy for learning and performance*
6. *Test anxiety*

Revision and validation of the SMS questionnaire during second stage
During the second stage of pilot study, the items in 'Science Motivation Scale' (SMS) (i.e. the instrument that was adapted from selected items from MOTS, SMQ and MSLQ) were psychometrically refined and pilot-tested again at least twice. To establish test-retest reliability, the SMS instrument was pilot-tested among secondary students of about the same age groups in three schools (i.e. Case study School A, B and Pilot study School C) at different phases in the year 2008 during lull periods when students were not involved in examinations.

This paper reports only on the last two pilot studies of SMS (henceforth being referred to as Pilot Study 1 and Pilot Study 2). Based on the statistical analysis from RA, FA and mean correlation, as well as feedback by student respondents and teachers with regards to the readability of items, the first refined version of SMS questionnaire consisted of 53 items was piloted among secondary samples mainly consisted of moderate and low achievers (N_1=160) in Pilot Study 1. However, the analysis of FA (that initially yielded 6 subscales to be illustrated in 'Data analysis' section) did not show good variance of score even if the eigenvalue was above 1 with reasonable mean correlation. Although the Cronbach's Alpha (CA) values of 3 subscales were identified marginal (0.73, 0.83 and 0.71) and 3 subscales were inadequate (0.66, 0.62 and 0.61), the overall internal reliability, established using CA value was measured at 0.87. In addition, deleting any of the 53 items did not increase the reliability of SMS. This indicated that all the items contributed to the reliability of SMS. It can thus be claimed that the items in SMS have high internal consistency and none of them should be dropped from the overall measure of students' motivation towards science.

Thus the SMS instrument was refined with 14 items recasted and 1 item deleted due to repetition. SMS (with revised 52 items including 38 original items and 14 recasted items) was pilot-tested again in Pilot Study 2 among secondary samples (N_2=182) consisted of mainly high and moderately high achievers (Refer ***Table 1***). The following section will elaborate on data analysis using statistics tool.

Data Analysis And Findings

This section elaborates on the steps involved in data analysis using SPSS statistical software with brief illustration and summary of the output of analysis to establish reliability and validity of SMS.

The procedures involved in pilot studies with implementation of statistical tool
The following were the procedures for RA, FA and mean correlation with discussion on decision made to retain and/or classify items in the subscales according to the underlying traits or constructs:

1. Conduct *Reliability Analysis* (RA) using Cronbach's Alpha (CA), i.e. the internal consistency reliability coefficient which is based on the average correlation of items within a test. CA is a measure of how well each individual item in a subscale correlates with the sum of the remaining items. The recommended acceptable range of CA between 0.7 and 0.9 for the two research instruments developed for this study was followed. Moreover, an item may be deleted if it has low *Corrected Item-Total Correlation* (e.g. below 0.3 or 0.2) and high *Alpha if Item Deleted* considering various other factors (Creswell, 2005; Phillips, 2007a). CA can be computed using SPSS statistics software by clicking the icons of "Analyze → Scale →Reliability Analysis" (Refer ***Figure 1*** and ***2***).

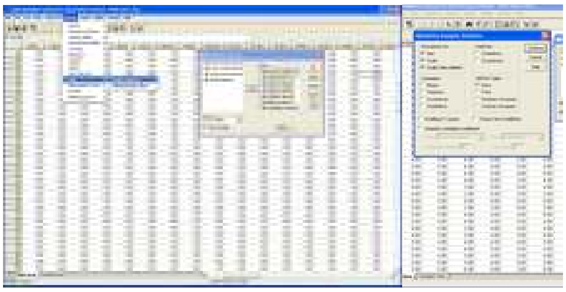

Figure 1 Conducting reliability analysis (RA) using SPSS statistics software

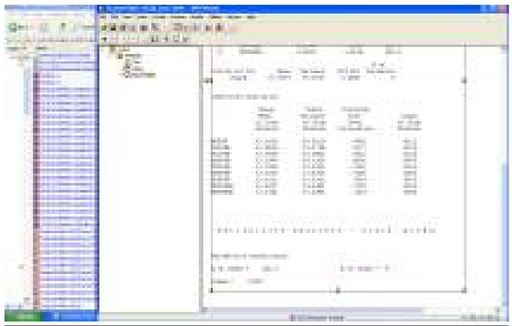

Figure 2 The output of RA for SMS scale 1 with CA value of 0.92

2. Conduct *Factor Analysis* (FA) following the steps, i.e. (1) Make several assumptions, e.g. ensure sample size is adequate, i.e. a minimum of 5 subjects per variable, or a sample of 100 subjects that is acceptable. Although FA is robust to assumptions of normality, if variables are proved to be normally distributed, then the solution is enhanced. Potential outliers may also be removed and negative items be recoded; (2) Compute the correlations between the items and ensure factorability by (a) examining the *correlation matri*x with a considerable number of the *correlation* exceeds 0.3; (b) examining Kaiser-Meyer-Olkin (KMO) measure of *sampling adequacy* and Bartlett's *test of sphericity* to check whether the data are likely to factor well, based on *correlation* and *partial correlation*. If KMO is greater than 0.6 as well as Bartlett's test is large and significant, then *factorability* is assumed; (3) Extract the factors with *Principal Component Analysis*, *Total Variance Explained* including 'Eigenvalues (more than one), *Extraction and Rotation Sums of Squared Loadings*' and the Scree Test; The rationale for the latent root or *eigenvalues* criterion is that any individual factor should account for the variance of at least a single variable if it is to be retained for interpretation. Each variable contributes a value of 1 to the total eigen-value. Thus only the factors having *latent roots* or *eigenvalues* greater than 1 are considered significant; (4) Perform rotation via *varimax rotation* to make the factors more interpretable and reduce the number of complex variables by suppressing absolute values less than 0.35. *Varimax rotation* is one of the most popular orthogonal factor rotation methods that produces easier interpretation of factors that are unrelated to or independent of one another. Factor rotation results in factors on which only some variables load and ensure in variables that load on only one factor. Items with double and triple loadings will be considered to be deleted or modified. These items may be retained if the second or third factor loading(s) are relatively weak (e.g.0.353) as compared to its much dominant loading in that subscale (e.g.0.712) (Bryman & Cramer, 1998; Creswell, 2005; Hair, Anderson, Tatham & Black, 1998; Phillips, 2007a); (5) Observe the percentage of variance criterion that is an approach based on achieving a specified cumulative percentage of total variance extracted by successive factors. This is to ensure practical significance of the derived factors by ensuring that they explain at least a specified amount of variance. Ideally the cumulative percentage of total variance extracted for the factors should be 70 percentage, or in natural sciences should be at least 95 percent. However, in the social sciences (including educational settings), where information is often less precise, it is not uncommon to consider a solution that accounts for 60 percent of the total variance (and in some instances even less) as satisfactory. With correlation or covariance matrices based on observed data in the social sciences, however, a clear-cut determination of the rank of a matrix is seldom possible. Apart from the problem of estimating communalities, observed data are subject to fluctuations due to the *sampling of individuals* and *errors of measurement in the variables* being analysed (Hair, et al., 1998; Keeves, 1988); (6) The 'rule of 150' recommends at least 150 to 300 cases as ideal cases or sample size to do factor analysis (Hutcheson & Sofroniou, 1999 in Phillips, 2007a). With the sample size in the range of 150 to 185, only items with factor loading 0.45 and above will be retained (Creswell, 2005; Phillips, 2007a); (7) Naming of factors to be elaborated in the following paragraphs. CA can be computed using SPSS

statistics software by clicking the icons of "Analyze → Data reduction →Factor" (Refer illustrations in ***Figure 3*** to ***Figure 5***). AND/OR

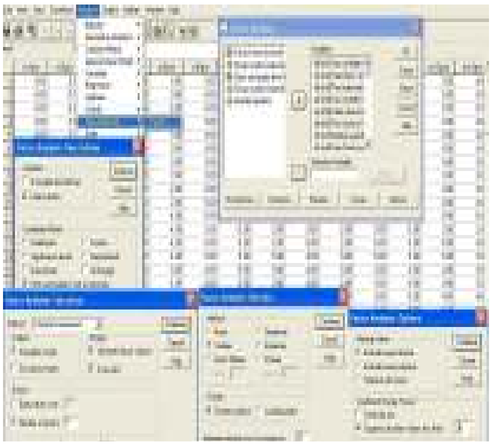

Figure 3 Conducting factor analysis (FA) using SPSS statistics software

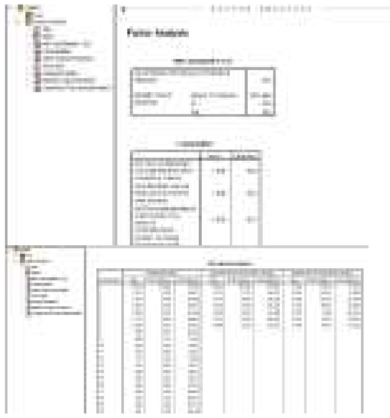

Figure 4 The output of FA for KMO, Eigenvalue and Variance

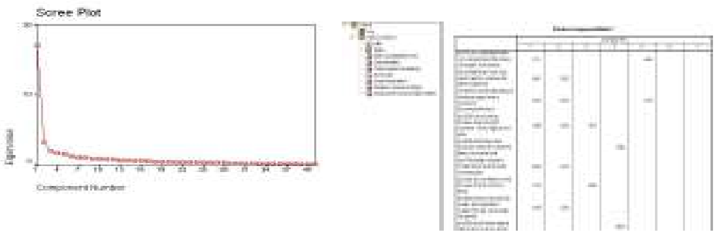

Figure 5 The output of FA for Scree plot and Rotated component matrix

3. Conduct *Mean Correlation* test to reconfirm the classification of the items of the subscale according to the constructs identified. RA will be done for each subscale, No.1 to 7, separately. The following is the summary of procedures for mean correlation using SPSS statistics software: (a) Run 'compute mean subscale' [i.e. ∑sum of mean (i.e.mean1+mean2…)/number of items] for each subscale, S1 to S7. (b) run 'correlation' study, i.e. analyze→correlate→bivariate→(S1 to S7)pre as variables→ Pearson, Means, S.D., Significant→ OK (Refer illustrations in ***Figure 6*** and ***8***). Ideally each subscale should have relatively high CA coefficient value ranged from 0.7 and above, and relatively low mean correlation ranged from 0.45 and below.

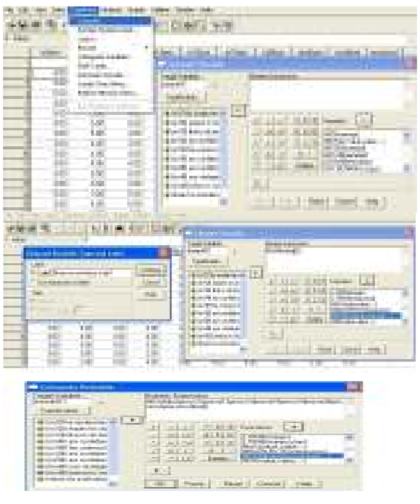

Figure 6 Conducting mean correlation using SPSS statistics software: Computing mean score for Scale 1

Figure 7 Conducting mean correlation: Analyze bivariate correlation

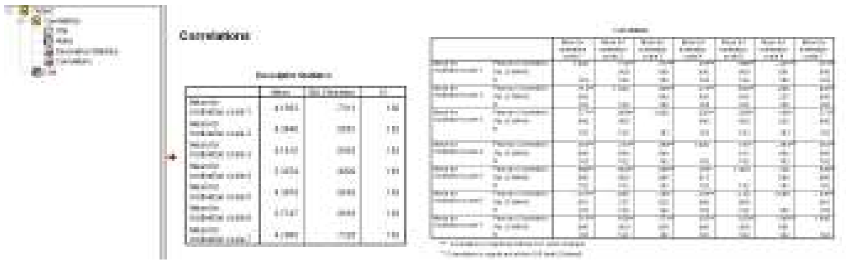

Figure 8 The output of mean correlation for descriptive statistics and means for motivation scales 1 to 7

Interpretation and discussions of findings from Pilot Study 1 and Pilot Study 2

This section presents the findings from the pilot studies of the SMS instrument. The first pilot study yielded six motivation subscales, i.e. (1) Values belief on science learning and its relevance (7 items); (2) Internally controlled science learning with intrinsic motivation (8 items); (3) Efforts and responsibility for learning science (6 items); (4) Self-efficacy beliefs and expectancy for learning (7 items); (5) Worthiness of science for all (4 items); (6) Anxiety about science assessment (6 items). After data analysis using statistics tool in second pilot study including revision to retain items with clarity and readability based on feedback by respondents, a final version of SMS was devised (refer **Table 1**) with revised post-hoc subscales consisted of parsimonious range of seven coherent groups (refer **Table 2**).

For the final version of SMS, it was found from statistical analysis that the instrument had relatively high reliability, ranged from approximately 0.68 to 0.92 for all 7 subscales and relatively low average mean correlation ranged from 0.17 to 0.49 (refer ***Table 2***). These mean correlations indicate that each subscale in the SMS questionnaire appears to reflect what the subscale should measure although somewhat they overlap with the other subscales. Thus, this study confirmed that the SMS questionnaire is a relatively reliable instrument for assessing learners' perceived levels of motivation towards science learning. Moreover, confirmatory factor analysis was conducted on the basis of a pre-established framework. With a sample size between 150 to 200, the researchers had decided to retain the items with factor loadings in the significance range of 0.45 and above (Phillips, 2007a). The analysis of Kaiser-Meyer-Olkin (KMO) measure of *sampling adequacy* and Bartlett's *test of sphericity* also showed that KMO is 0.92 (i.e. greater than 0.6) and Bartlett's test is large with Chi-Square value of 5572.97 and significant at 0.000. Thus the *factorability* of the data is assumed based on *correlation* and *partial correlation*. Further statistical analysis also showed the acceptable range of Eigenvalue (more than 1) and Variance (67.4%) for SMS instrument to be a valid instrument.

Conclusion

Although Science Motivation Scale (SMS) was successfully piloted with reasonably good results of reliability and factor analysis, various issues were identified to be deliberated in this section.

Limitations and significance of study

SMS was mainly designed to evaluate students' perceived levels of motivation with less concrete examples of their real intended involvement. The difficulties faced in terms of time and accessibility to research samples of diverse levels of academic achievement are obviously two main constraints for the pilot studies to be conducted smoothly. This was due to the fact that SMS was planned to be administered as one of the pre-tests for the aforementioned PBL study which was conducted at the second half of the year when many important public and school examinations were to be held. Moreover, as the PBL study was targetted to be conducted among students of moderate and low achievement, the researcher was initially rather concerned about the construct of the SMS items may not be comprehensive enough to ensure reasonable reliability and construct validity of the instrument. As such, apart from adapting items from the three aforementioned validated instruments, i.e. MOTS, SMQ and MSLQ, the first draft of SMS instrument was initially administered among six selected high achievers to ensure readability of items before it was distributed among a group of moderate and low achievers. However, the results obtained from the first pilot study during the second stage did not show good statistical findings in terms of variance.

Table 1 An Analysis of First (N_1=160) and Second (N_2=182) Piloted Items in Science Motivation Scale (SMS) with Summary of Decision Made to Retain or Remove the Items

Item No.	Statements *(as listed in the first piloted questionnaire)*	Decision based on the Pilot Study 1	Item No.	Statements *(as listed in the edited second piloted questionnaire)*	Decision based on the Pilot Study 2	Item No.
1	I think about how learning science can help me get a good job.	To be recasted to Item (1) as it is a repetition of Item 17.	1	(New Item 1: See bottom after No. 19)	-	-
			39(1)	I think about how learning science can help me achieve my ambition (Recasted)	MS6 after Factor Analysis(FA) in Pilot Study 2 (refer Table 2 below)	1
2	The science I learn relates to my personal goals.	To be deleted. (1) Not fit into intended MS4 after FA. (2) Students (X2) responded not understand the statement.	2	(New Item 2: See bottom after No. 32)	-	-
			40(2)	The science I learn relates to my ambition. (Recasted from old No. 2)	To be removed as double loading.	-
3	The understanding of science gives me a sense of accomplishment.	Motivation Scale(MS) 1 after Factor Analysis(FA) in Pilot Study 1	3	The understanding of science gives me a sense of accomplishment.	MS1 after FA in Pilot Study 2 (refer Table 2 below)	2
4	I am confident I will do well in science projects.	MS3 after FA. Retained as it increases the reliability of MS3 for mean correlation (although double loading).	4	I am confident I will do well in science projects.	To be removed as it consists of Factor Loading (FL) less than 0.3.	-
5	I think about how my science grades will affect my overall average.	MS3 after FA in Pilot Study 1	5	I think about how my science grades will affect my overall average.	To be removed. Less than 0.3 FL.	-
6	The science I learn is more important to me than the grade I receive.	MS1 after FA in Pilot Study 1	6	The science I learn is more important to me than the grade I receive.	To be removed. Less than 0.3 FL.	-
7	Getting a good science grade is important to me.	MS3 after FA in Pilot Study 1	7	Getting a good science grade is important to me.	To be removed. Less than 0.3 FL.	-
51	To score good results in science gives me my satisfaction.	To be deleted. (1) Not fit into MS2. (2) Students don't understand.	41(3)	I feel satisfied if I can score good results in science. (Recasted from No. 51 in the first/1^{st} pilot questionnaire)	To be removed as it reduce The reliability of MS7.	-
8	I feel worried whenever I take my science tests.	MS1 after FA.Edited refer to comments	8	I feel worried whenever I take my science tests.	To be removed. Less than 0.3 FL.	-
9	I always think about how I will use the science I learn.	MS2 after FA in Pilot Study 1	9	I always think about how I will use the science I learn.	To be removed. Less than 0.3 FL.	-
10	I think I'm very weak in science compared to my friends in class.	MS6 after FA in Pilot Study 1	10	I think I'm very weak in science compared to my friends in class.	To be removed. Less than 0.3 FL.	-
11	I prefer science materials that increase my curiosity.	MS2 after FA in Pilot Study 1	11	I prefer science materials that increase my curiosity.	To be removed. Less than 0.3 FL.	-
12	I expect to do as well as or better than other students in the science course.	MS3 after FA in Pilot Study 1	12	I expect to understand as well as or better than other students in the science course.	To be removed. Less than 0.3 FL.	-
13	I like to do better than the other students in the science tests.	MS3 after FA in Pilot Study 1	13	I like to understand better than the other students in the science tests.	To be removed. Less than 0.3 FL.	-
14	I am confident that I can acquire skills taught in science	MS4 after FA in Pilot Study 1	14	I am confident that I can acquire the skills taught in science.	To be removed. Less than 0.3 FL.	-

15	The science I learn has practical value for me.	MS1 after FA in Pilot Study 1	15	The science I learn has practical value for me.	To be removed as triple loadings.	-
16	I prepare well for the science tests and lab activities.	MS1 after FA in Pilot Study 1	16	I prepare well for the science tests and laboratory activities.	To be removed as triple loadings.	-
17	I think about how learning science can help me get a good job.	MS5 after FA in Pilot Study 1	17	I think about how learning science can help me get a good job.	MS6 after FA in Pilot Study 2 (refer Table 2 below)	13
18	If I learn in a proper way, I will succeed in learning science.	To consider to be removed. Double loading after FA.	18	(New Item 18: See bottom same line with No. 48 in 1st pilot SMS)	-	-
			42(4)	If I learn in a proper way, I will be successful in science learning. (Recasted from old item No.18)	MS7 after FA (refer below). Retained as it increases the reliability of MS7.	4
19	I am confident that I can understand the difficult topics in science.	MS4 after FA in Pilot Study 1	19	I am confident that I can understand the difficult topics in science.	MS1 after FA (refer below). Retained as it has much dominant loading.	5
52	I am confident that I can understand the basic concepts in science.	MS2 after FA in Pilot Study 1. Q1 in revised SMS.	1	I am confident that I can understand the basic concepts in science.	To be removed as double loading, also got another better item No.19.	-
20	It is my fault, if I do not understand science.	To be removed Less than 0.3 FL.	20	(New Item 20: See bottom same line with No. 40 in 1st pilot SMS)	-	-
21	Science learning is relevant to my life.	MS1 after FA in Pilot Study 1	21	Science learning is relevant to my life.	MS2 after FA (refer below)	6
22	I find science learning interesting.	MS2 after FA in Pilot Study 1	22	I find science learning interesting.	To be removed as double loading.	-
23	I think science materials are important for me to learn.	MS1 after FA in Pilot Study 1	23	I think science materials are important for me to learn.	To be removed as double loading.	-
24	I am nervous about how I will do in the science tests.	MS6 after FA in Pilot Study 1	24	I am nervous about how I will do in the science tests.	MS4 after FA (refer below)	7
25	If I am having trouble learning the science, I try to figure out why.	MS4 after FA in Pilot Study 1	25	If I am having trouble learning the science, I try to figure out why.	To be removed as triple loadings.	-

(continued)

Item No.	Statements *(as listed in the first piloted questionnaire)*	Decision based on the First pilot study	Item No.	Statements *(as listed in the edited second piloted questionnaire)*	Decision based on the Second pilot study	Item No.
26	I become anxious when it is time to take a science test.	MS6 after FA in Pilot Study 1	26	I become anxious when it is time to take a science test.	MS4 after FA (refer Table 2 below)	8
27	I prefer science materials that are quite challenging.	MS1 after FA in Pilot Study 1	27	I prefer science materials that are quite challenging.	MS1 after FA (refer Table 2 below)	9
28	I am confident I will do well in the science tests.	MS2 after FA in Pilot Study 1	28	I am confident I will do well in the science tests.	MS1 after FA(refer Table 2 below)	10
29	I use strategies that ensure I learn the science well.	To consider to be removed. Double loading after FA.	29	(New Item 29: See same line with No. 39 in 1st pilot, recasted)	-	-
			44(6)	I use strategies that can help me to learn science better. (Recasted from No.29)	MS1 after FA in Pilot Study 2 (refer Table 2 below)	11
30	I worry about failing the science tests.	MS6 after FA in Pilot Study 1	30	I worry about failing the science tests.	MS4 after FA (refer Table 2	12

					below)	
31	A scientific career might be right for some people but not for me.	To consider to be removed. Not fit into MS2 after FA.	31	(New Item 31: See bottom same line with No. 41 in 1st pilot SMS)	-	-
			45(7)	A scientific career may be suitable for me. (Recasted from the old No.31)	To be removed as double loading.	-
32	I need science to learn other school subjects.	MS4 after FA in Pilot Study 1	32	I need science to learn other school subjects.	MS7after FA (refer Table 2 below)	3
53	I feel that I can use what I get in science for other subjects.	MS4 after FA in Pilot Study 1. Q2 in revised SMS	2	I feel that I can use what I get in science for other subjects.	To be removed as triple loadings.	-
33	I can have a successful career related to science if I work hard enough.	MS2 after FA in Pilot Study 1	33	I can have a successful career related to science if I work hard enough.	To be removed as triple loadings.	-
34	Students should ~~NOT~~ be encouraged to take science courses at university level.	To consider to be removed. Not fit into MS2 after FA.	34	(New Item 34: See bottom after No. 38)	-	-
			46(8)	Students should be encouraged to take science courses. (Recasted from No.34)	To be removed as double loading.	-
35	Girls and boys are both encouraged to take science.	MS5 after FA in Pilot Study 1. Edited based on comments.	35	Girls and boys are both encouraged to take science.	MS5fter FA (refer Table 2 below) Retained to increase reliability	14
36	Science is always difficult to understand.	To consider to be removed. Double loading.	36	(New Item 36: See bottom same line with No. 46 in 1st pilot SMS)	-	-
			47(9)	Science is not that difficult to understand. (Recasted from old No.36)	MS1 after FA (refer Table 2 below)	15
37	I feel the study of science in school is important.	MS2 after FA in Pilot Study 1	37	I feel the study of science in school is important.	MS2 after FA (refer Table 2 below)	16
38	Scientific knowledge is useful in keeping our national economy competitive.	To consider to be removed. Double loading after FA.	48(10)	Scientific knowledge is useful for the development of our country. (Recasted from old No.38 in 1st pilot instrument)	MS5fter FA (refer Table 2 below)	17
39	Science should ~~NOT~~ be made an important subject for all secondary students.	MS5 after FA in Pilot Study 1. Q29 in revised SMS.	29	Science should be made an important subject for all secondary students.	To be removed as double loading.	-
40	Taking up science as a career would be well worth the time and effort required.	MS4 after FA in Pilot Study 1. Q20 in revised SMS.	20	Taking up science as a career would be well worth the time and effort required.	To be removed as triple loadings.	-
41	I think learning science will help me in my daily life.	MS4 after FA. Q31 in revised SMS.	31	I think learning science will help me in my daily life.	MS2 after FA (refer Table 2 below)	18
42	My target is to succeed in science.	MS2 after FA. Q38 in revised SMS.	38	My target is to succeed in science.	MS2 after FA (refer Table 2 below)	19
43	Everyone should learn about science.	MS5 after FA in Pilot Study 1. Q34 in revised SMS.	34	Everyone should learn about science.	To be removed as triple loading and student responded	-

					negatively.	
44	A career in science would be very satisfying.	To be deleted. (1) Not fit into MS4. (2) Student responded not understand.	49(11)	I can gain job satisfaction from a science career. (Recasted from old No.44 in the 1st pilot instrument)	MS3fter FA (refer below) Retained though double loading as increases RA.	20
45	Science exist for the benefit of mankind.	To consider to be removed. Not fit into MS4 after FA.	50(12)	Science exist for the benefit of mankind.	MS7after FA in Pilot Study 2. (refer Table 2 below)	21
46	I do well in science because I have studied hard.	MS3 after FA. Q36 in revised SMS.	36	I do well in science because I have studied hard.	To be removed as double loading.	-
47	When I persist in solving problems, it is because I am motivated.	To consider to be removed. Triple loading after FA.	51(13)	When I persist in solving problems, it is because I am motivated towards science learning. (Recasted from No.48)	MS3fter FA (refer below) Retained although double loading as it increases the reliability of MS3.	22
48	Whenever I am taking the science examination, I always think of the bad effects if I fail.	MS6 after FA in Pilot Study 1. Q18 in revised SMS.	18	Whenever I am taking the science examination, I always think of the bad effects if I fail.	MS4 after FA in Pilot Study 2 (refer Table 2 below)	23
49	If I cannot understand science, it is because I do not try my best.	To consider to be removed. Not fit into MS6 after FA.	43(5)	If I cannot understand science, it is because I do not try my best.	MS3fter FA (refer below) Retained as it increases the reliability of MS3.	24
50	I always think that getting along with people is a skill that can be practised.	To consider to be removed. Not fit into MS5 after FA.	52(14)	I always think that working with other project team members is a skill that can be practiced. (Recasted from No.50)	MS5fter FA in Pilot Study 2 (refer Table 2 below)	25

Table 2 *Factor Loadings, Cronbach's Alpha (CA) Coefficients and Mean Correlation of Each Subscale of SMS for the Second Pilot Study (N_2=182)*

No	Subscale(s) and Item(s)	Factor Loadings	Cronbach's Alpha (CA)	Mean Correlation
1	***Self-efficacy belief for learning and performance***		**0.92**	**0.49**
	Item 3 (revised Pilot Study 2) or Item 2 (latest draft)	0.623		
	Item 19 (Pilot Study 2) or Item 5 (latest draft)	0.712		
	Item 27 (Pilot Study 2) or Item 9 (latest draft)	0.682		
	Item 28 (Pilot Study 2) or Item 10 (latest draft)	0.732		
	Item 44 (Pilot Study 2) or Item 11 (latest draft)	0.671		
	Item 47 (Pilot Study 2) or Item 15 (latest draft)	0.770		
2	***Expectancy and goal oriented science learning***		**0.84**	**0.41**
	Item 21 (Pilot Study 2) or Item 6 (latest draft)	0.578		
	Item 31 (Pilot Study 2) or Item 18 (latest draft)	0.740		
	Item 37 (Pilot Study 2) or Item 16 (latest draft)	0.668		
	Item 38 (Pilot Study 2) or Item 19 (latest draft)	0.765		
3	***Intrinsic motivation with efforts for science***		**0.75**	**0.46**
	Item 43 (Pilot Study 2) or Item 24 (latest draft)	0.551		
	Item 49 Pilot Study 2) or Item 20 (latest draft)	0.657		
	Item 51 (Pilot Study 2) or Item 22 (latest draft)	0.593		
4	***Anxiety about science assessment***		**0.90**	**0.27**
	Item 18 (Pilot Study 2) or Item 23 (latest draft)	0.806		
	Item 24 (Pilot Study 2) or Item 7 (latest draft)	0.871		
	Item 26 (Pilot Study 2) or Item 8 (latest draft)	0.796		
	Item 30 (Pilot Study 2) or Item 12 (latest draft)	0.884		
5	***Values belief on science knowledge and skills***		**0.70**	**0.37**
	Item 35 (Pilot Study 2) or Item 14 (latest draft)	0.620		
	Item 48 (Pilot Study 2) or Item 17 (latest draft)	0.690		
	Item 52 (Pilot Study 2) or Item 25 (latest draft)	0.599		
6	***Aspiration for science learning***		**0.77**	**0.17**
	Item 17 (Pilot Study 2) or Item 13 (latest draft)	0.813		
	Item 39 (Pilot Study 2) or Item 1 (latest draft)	0.801		
7	***Perceived worthiness of science venture***		**0.68**	**0.46**
	Item 32 (Pilot Study 2) or Item 3 (latest draft)	0.560		
	Item 42 (Pilot Study 2) or Item 4 (latest draft)	0.632		
	Item 50 (Pilot Study 2) or Item 21 (latest draft)	0.434		

As such the final pilot study of SMS was conducted among a group of 182 male and female secondary students who are mostly high achievers with inclusion of some moderately high achievers. The final version of SMS showed Cronbach Alpha (CA) value of 0.96 and eigenvalues more than 1 with reasonably good specific cumulative percentage of total variance extract by successive factors at the value of 67.4%. Thus the SMS showed practical significance for the derived factors that explain at least a specific amount of variance (Hair, et al., 1998) for the instrument to be used in the subsequent studies.

Implications and more research activities

The following are some observations made throughout the researcher's involvement in piloting the SMS instrument with reflections on research implications:

- The findings from the pilot studies concurred with those from the literature which revealed that the analysis of data is affected by the types of responses received from the test respondents and how the factor analysis is done. For example, there were slight differences (with some degrees of overlaps) of the types of items that were classified under the motivation subscales identified in pilot study 1 (involving mostly moderate and low achievers) when compared to pilot study 2 (involving mostly high and moderately high achievers). However, irrespective of how many times the researcher implemented factor analysis, the reverse-scored items [as adapted from the '*Assessment anxiety*' subscale by Glynn, et al. (2007) and '*Test anxiety*' subscale by Pintrich, et al. (1993)] will still fall under the same category of "*Anxiety about science assessment*" with very good Cronbach Alpha and factor loadings. It is thus proven that 'science assessment' is always a great concern of school students of various achievement levels For example, one high achiever responded to the item "I feel worried whenever I take my science tests" with feedback "because it will affect my average".

- Moreover the analysis of the first and second pilot studies showed that better results were yielded from the data collected from pilot study 2 mainly involving high-achievers who seemed to give more valid responses on their perceived levels of motivation. It is thus advisable that the pilot study of research instruments should involve more high achievers to ensure better realiability and validity of test even though moderate and low achievers were involved in the subsequent real studies. To further reconfirm the classification of items in the subscale according to the constructs identified, it is also advisable that mean correlation with RA could be computed.

- Some of the pilot study respondents in the high achievers groups had also responded to the SMS test with qualitative feedback on some items. For example, high achievers seemed to show high self-awareness or metacognitive thinking on their own strengths, weaknesses including their learning strategies that affect their motivation towards science. They were very concerned with their science performance as compared to their friends in class and were able to give specific subject areas, such as Physics or Chemistry. One student also expressed his concern that "He expect to 'understand' (but not 'do') as well as or better than other students in the science course or tests". Other statements extracted from the open-ended responses also reflected their perceived motivation levels towards science related learning and activities:

  > *...Is there any 'strategy that can help me to learn science better'?...Is the 'proper way for successful science learning' referred to conventional book reading or PBL?...'Students should be encouraged to take science courses' but equal distribution of professions should be given for students…It's the person, not 'science' itself that 'exist for the benefit of mankind…I don't mind doing puzzles or problems related to science at school…'I can have a successful career related to science if I work hard' and smart enough…Tests only compare us against a paradigm…*
  >
  > (Pilot study students in School C)

From the qualitative feedback by pilot study samples, the researcher may also gather some hints or infer that secondary students appreciated if they know strategies to learn science better, to have good professions, and to have good science teachers. As such there is a need to consider revising effective pedagogies to enhance students' motivation in science learning.

Apart from SMS, another motivation questionnaire, i.e. the 'Motivation Towards Science Learning Survey' (MTSLS) was adapted from validated instruments e.g. 'Thinking about Science Survey Instrument' (TSSI) by Cobern (2000) and 'Participation in Science and Mathematics-Oriented Activities' (PSMA) Inventory by Cabanilla-Pedro, et al. (2005). This instrument with 70 items was also pilot-tested among 148 secondary male and female students in three local schools in August 2008 with reliability analysis of Cronbach Alpha's value of 0.94. The data obtained from MTSLS questionnaire will supplement the findings (with more concrete examples of students' intended participation in science related learning and career) from SMS which was mainly designed to evaluate students' perceived levels of motivation with less concrete examples of their intended involvement. Moreover, mixed-research method will also be implemented in the real study to triangulate findings from the data obtained from observation, interviews and documentary analysis of students' learning output in addition to SMS and MTSLS motivation questionnaires.

The findings from pilot studies of SMS showed that it is valid and reliable to some extent to evaluate students' perceived levels of motivation towards science. Moreover, literature revealed that the study of students' motivation has great implications in educational settings, as stated earlier, '*knowledge, skills and motivation are essential pre-conditions in scientific creativity*' (Down, 1991). It is thus recommended that more research activities should be conducted to include the evaluation of students' motivation before introducing science curriculum incorporating effective teaching pedagogies.

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